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ZOOPLANKTON OF SAKARYABAŞI-WEST POND, CENTRAL ANATOLIA

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ABSTRACT. The study was conducted between March 2017 and February 2018 to determine the effects various applications and environmental impacts on zooplankton composition in Sakaryabaşı-West Pond. Zooplankton samples were monthly collected with plankton net vertically and horizontally from two stations as triplicated. At the time of sampling, water temperature, dissolved oxygen, pH, electrical conductivity, water depth and light transparency were measured at the stations. Rotifera was the highest proportion in the pond during the study, followed by Copepoda and Cladocera, respectively. At this research, 11 families from Rotifera, 22 species from Cladocera, 1 family from Cladocera, 1 family from Copepoda. Proportionally most common species were *Lepadella patella* (6.38%), *Mytilina ventralis* (5.32%), *Lecane lunaris* (4.79%) from Rotifera; *Alona rectangula* (8.51%) from Cladocera. Cyclopoidae copepods was formed as adults (17.55%), nauplii (25.53%). During the study period the average zooplankton abundance ranged from 3 ± 0.5 x10^3 to 36 ± 2 x10^3 / m^3. The highest abundance value was determined in October and the lowest abundance value was determined in January. As a result, regular monitoring of zooplankton in Sakaryabaşı-West Pond as an indicator of the ecological health of the water bodies, will be important in terms of being a warning for the negative impacts of the pond.

1. INTRODUCTION

Most of the lakes and ponds are very important ecologically and they have risk of eutrophication or drying. The first step in the ecological improvement of such lakes is to reveal their condition by examining the structure of their biological communities. In aquatic systems, the zooplankton is functionally important by consuming phytoplankton and bacteria and as a prey for higher levels of fish in the

Keyword and phrases. Sakaryabaşı-West Pond, zooplankton, water quality parameters.

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food chain. Therefore, it is an important indicator of ecosystem health [1]. Water quality, hydrology, nutrient content and presence of submerged plants, being exposed to predation by planktivorous fish in water bodies caused differences in shape and movements of zooplankton in their communities [2] [3] .

Sakaryabaşı-West Pond is fed by one of the karst springs that originates Sakarya River and that was converted to a pond with the construction of a set in the 1970s. This pond also supplies water to the Fish Culture and Research Station of Ankara University through a concrete channel. Because of its spring origin, the water temperature of the pond is stable and decreases to a minimum of 13°C in the winter [4]. The lake exceeded the eutrophication limit due to agricultural activities and intensive fertilizer use at the around of the West Pond and the lake was hypertrophic in terms of total phosphorus concentration [5].

The zooplankton composition of the pond was determined by Demir and Kırkağaç in 2005. In 2006, grass carp was stocked in order to control the aquatic plants in the pond and than the effects of grass carp on zooplankton composition was exhibited [6]. However, uncontrolled fishing eliminated grass carp from the pond and the existence of European catfish, tilapia and carp from unknown sources was determined over the years.

In this study, it is aimed to reveal to what extent some lake management activities and environmental conditions in the West Pond effected the zooplankton composition and to determine its present situation.

2. Materials and Methods

Sakaryabaşı-West Pond is located at 39º21º15º-39º21º37º and 31º02º 22º -31º 02º 59º in Central Anatolia (Figure 1). The volume and surface area of the pond is 26000m^3 and 0.92 ha, respectively. It supplies water to Ankara University Sakaryabasi Fish Culture and Research Station through a concrete channel with a flow of 430 l s^{-1}. The retention time of the pond was calculated as 0.6 day^{-1}. The altitute of the pond from sea level is about 870 m. Total hardness value of the pond is between 49-55 FS^0 and calcium hardness is between 36.7-76.9 mg / l. The pond water is in hard water class. Also, the pond is eutrophic in terms of orthophosphate and total phosphorus concentrations [7,8,4,6,9]. The fisheries station produces 40 tons of rainbow trout per year together with some other fish species such as cyprinids, European catfish, tilapia, and sturgeon. In recent years, it has been reported that cyprinids, European catfish and tilapia are found in the Pond.

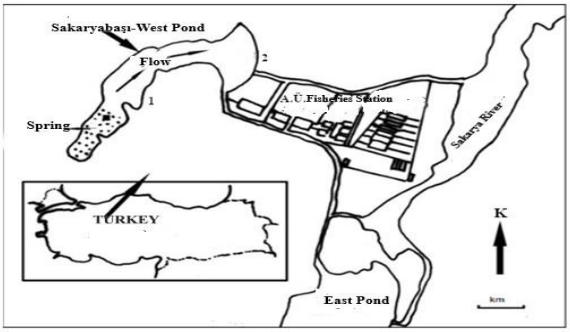

FIGURE 1. Sakaryabaşı-West Pond and sampling stations

The research was carried out for one year between March 2017 and February 2018. Zooplankton samples were collected from two stations: one near the spring, the other is near the set (Figure 1). Samples were collected vertically and horizontally by a plankton net with 55µm mesh size, triplicately for qualitative and quantitative analysis. The water temperature (°C), dissolved oxygen (mg/l), pH, conductivity (µS/cm) (CONSORT C5020T MODEL), depth (cm) and Secchi depth (cm) were measured *in situ*.

Zooplankton samples were taken into 250 ml containers, fixed with 4% formaldehyde and transferred to the laboratory [10,11]. The usual taxonomic literature was used for identifying the zooplankton samples under invert and binocular microscopes [12,13,14,15,16,17,18,19]. Zooplankton samples were counted from five subsamples each containing 1 ml under inverted microscopes [12]. Abundances were calculated according to [10,20,21]. The zooplankton abundances values were given as individual per m^3.

Statistical analysis were carried out by using SPSS 17 Statistic Program. Variance analysis (ANOVA), Duncan multiple range test and t-test were computed to evaluate the data [22].

3. RESULTS

Zooplankton community composed of 11 families and 22 species from Rotifera, 1 family and 2 species from Cladocera and 1 family and 1 genus from Copepoda were

identified (Table 1). In Sakaryabaşı-West Pond, the presence of zooplankton species in stations by months is given in Table 2. Cyclops sp. from cyclopoid copepod was mostly found in nauplii stage as well as copepodit and adult stage. Lecane lunaris, Lepadella patella ve Mytilina ventralis were mostly found species in the stations by the months while the other rotifer species were encountered only in one month during the study.

TABLE 1. Zooplankton list of Sakaryabaşı-West Pond

Division	Class/Subclass	Order/Family	Species
Rotifera	Monogononta	Gastropodidae	*Ascomorpha ecaudis* (Perty,1850)
		Collothecidae	*Collotheca ornata* (Ehrenberg, 1830)
		Lepadellidae	*Colurella obtusa* (Gosse, 1886)
		Euchlanidae	*Euchlanis dilatata* (Ehrenberg, 1832)
		Branchionidae	*Keratella cochlearis* (Gosse, 1851) *Keratella valga* (Ehrenberg, 1834) *Notholca acuminata* (Ehrenberg, 1832)
		Lecanidae	*Lecane bulla* (Gosse, 1851) *Lecane flexilis* (Gosse, 1886) *Lecane furcata* (Murray, 1913) *Lecane hornemani* (Ehrenberg, 1834) *Lecane luna* (Müller, 1776) *Lecane lunaris* (Ehrenberg, 1832) *Lecane obtusa* (Murray, 1913)
		Lepadellidae	*Lepadella patella* (Müller, 1773)
		Mytilinidae	*Mytilina bisulcata* (Lucks, 1912) *Mytilina mucronata* (Müller, 1773) *Mytilina ventralis* (Ehrenberg, 1830)
		Testudinellidae	*Pompholyx sulcata* (Hudson, 1885) *Testudinella elliptica* (Ehrenberg, 1834)
		Trichotriidae	*Trichotria pocillum* (Müller, 1776)
		Trichocercidae	*Trichocerca cylindrica* (Imhof, 1891)
Arthropoda	Branchiopoda	Cladocera/ Chydoridae	*Alona rectangula* (G.O. Sars, 1862) *Chydorus sphaericus* (O.F. Müller, 1776)
	Maxillopoda	Copepoda/ Cyclopidae	*Cyclops* sp.

TABLE 2. The presence of zooplankton species by months in Sakaryabaşı-West Pond

	Months											
	March	Apr	May	June	July	August	Sept	Oct	Nov	Dec	Janu	Febr
Rotifera												
Ascomorpha ecaudis	-	-	-	-	-	-	1*	-	-	-	-	-
Collotheca ornata	1.2*	-	1	1	-	-	-	2	-	-	-	-
Colurella obtusa	-	-	-	-	-	-	-	2	-	-	-	-
Euchlanis dilatata	-	-	-	-	-	2	1.2	2	-	-	-	-
Keratella cochlearis	-	-	-	1	-	-	-	-	-	-	-	-
Keratella valga	-	-	-	-	-	-	-	2	1.2	1	2	-
Lecane bulla	-	-	-	1	-	-	-	1	-	-	-	-
Lecane flexilis	-	-	-	1	2	-	-	1	-	-	-	-
Lecane furcata	-	-	-	1.2	-	-	-	-	-	-	-	-
Lecane hornemani	-	-	-	1	-	-	-	-	-	-	-	-
Lecane luna	-	-	-	-	-	-	-	1	-	-	-	-
Lecane lunaris	-	-	1.2	1.2	2	1	-	2	1	-	-	1
Lecane obtusa	-	-	-	2	-	-	-	-	-	-	-	-
Lepadella patella	-	-	-	1.2	1	1	1	1.2	-	2	-	-
Mytilina bisulcata	-	-	-	-	-	1.2	1.2	-	-	-	-	-
Mytilina mucronata	-	-	-	-	-	1.2	1	-	-	-	-	-
Mytilina ventralis	-	-	-	2	2	1.2	1	2	-	-	-	-
Notholca acuminata	-	-	-	-	-	-	-	-	-	-	1	-
Pompholyx sulcata	-	-	-	-	-	-	-	2	-	-	-	-
Testudinella elliptica	-	-	-	2	-	-	-	-	-	-	-	-
Trichotria pocillum	-	2	-	-	-	-	-	2	2	2	-	-
Trihocerca cylindrica	-	-	-	-	-	-	-	2	-	-	-	2
Cladocera												
Alona rectangula	1	2	1	1	2	1.2	-	1.2	-	-	-	-
Chydorus sphaericus	2	2	-	-	-	-	-	2	-	-	-	-
Copepoda												
Cyclops sp.	2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-	-	1.2	-
Nauplii	2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-	1	2	1.2

*1 : 1.station, 2: 2.station

Zooplankton abundance values of Sakaryabaşı-West Pond according to months and stations are given in Table 3. The variations in the average zooplankton abundance according to months and stations was evaluated by variance analysis and the differences were found statistically significant ($p<0.05$). However, the average zooplankton abundance values between the two stations in the months were evaluated with the t-test and the differences were found to be significant, except for May, June, July and November ($p <0.05$). During the study, the average zooplankton abundance changed between 3±0.5x103 and 36±2x103 individual /m3 .

TABLE 3. Zooplankton abundance according to months and stations in Sakaryabaşı-West Pond (Mean ± standard deviation) ($x10^3$) (individual / m^3)

Months	Stations	
	1	2
March	$5 \pm 1^{de*A**}$	14 ± 2^{dB}
April	9 ± 2^{cdA}	31 ± 0.5^{bB}
May	19 ± 4^{b}	17 ± 1^{c}
June	31 ± 2^{a}	31 ± 2^{b}
July	9 ± 2^{cd}	10 ± 0.6^{e}
August	$30 \pm 2^{a\,A}$	$14 \pm 1^{d\,B}$
September	12 ± 0^{cA}	17 ± 0.5^{cB}
October	12 ± 1^{cA}	36 ± 2^{aB}
November	5 ± 0.6^{e}	5 ± 1^{fg}
December	9 ± 2^{cdA}	$5 \pm 0.6^{f\,B}$
January	12 ± 0.6^{cA}	3 ± 0.5^{gB}
February	10 ± 0.4^{cA}	5 ± 1^{fgB}

*Means with the different small letters in the same line are significant statically ($p<0.05$).
** Means with the different capital letters in the same column are significant statically ($p<0.05$).

In the zooplankton community, the highest proportion in the pond belonged to group of Rotifera, followed by Copepoda and Cladocera, respectively (Figure 2). Considering the proportional distribution, the dominant species are *Lepadella patella* (6.38%), *Mytilina ventralis* (5.32%), *Lecane lunaris* (4.79%) from Rotifera; *Alona rectangula* (8.51%) is from Cladocera. The ratio of adults of *Cyclops* sp from Copepoda was 17.55%, and the nauplii stage was about 25.52%.

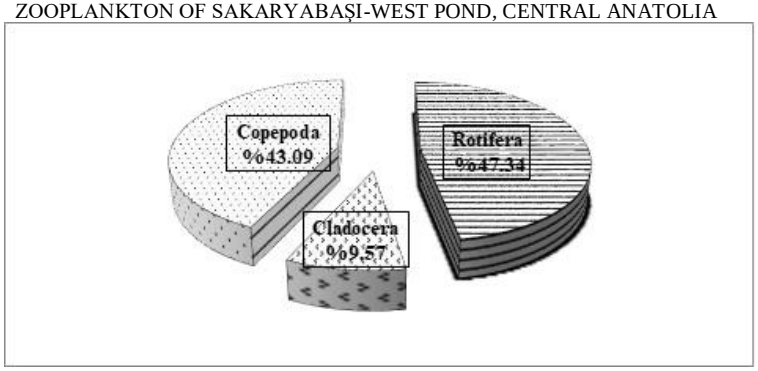

FIGURE 2. The proportional distribution of the zooplankton groups of Sakaryabaşı-West Pond (%).

The proportional distribution of the zooplankton groups at the stations according to the months in Sakaryabaşı-West Pond is given in Table 4. During the study, Rotifera was present in all stations and proportionally the highest value was in June (12%), October (10.6%) and August (7.4%), respectively. Cladocera was not encountered at the stations in September, November, December, January and February. On the other hand, Copepoda was found at the stations except November.

TABLE 4. The proportional distribution of the zooplankton groups according to the stations and months in Sakaryabaşı-West Pond (%)

Stations	Groups	Months											
		March	April	May	June	July	August	September	October	November	December	January	February
1	Rotifera	0.5	-	1.6	7	0.5	5.3	2.1	2.1	1	0.5	0.5	0.5
	Cladocera	0.5	-	1	0.5	-	1	-	0.5	-	-	-	-
	Copepoda	-	2	2.1	2.1	1.6	3.2	1.6	1	-	2.1	2.1	2.8
2	Rotifera	0.5	0.5	0.5	5	1.6	2.1	3.7	8.5	1	1	0.5	0.5
	Cladocera	0.5	3.2	-	-	0.5	0.5	-	1	-	-	-	-
	Copepoda	3.2	5.3	3.7	3.7	1	1.6	1.6	1.6	-	-	0.5	1

During the study, The water parameters were determined in terms of average temperature, dissolved oxygen, conductivity, pH and they were ranged from 14.80±0.65ºC to 28.56±0.55ºC (Figure 3), from 4.18±20 mg/l to 7.41±0.85mg/l (Figure 3), from 0.71±0.01 µS/cm to 0.85±0.03 µS/cm (Fig.4) and from 6.44±0.02 to 8.15±0.15, respectively. The average depth of Sakaryabaşı-West Pond was changed between 193±5.7cm and 198±2.8 cm in the 1. station, 213±5 cm and 223±5.7 cm in the 2. station, average transparency was about 156±5.7 cm and 218±2.8 cm (Figure 3).

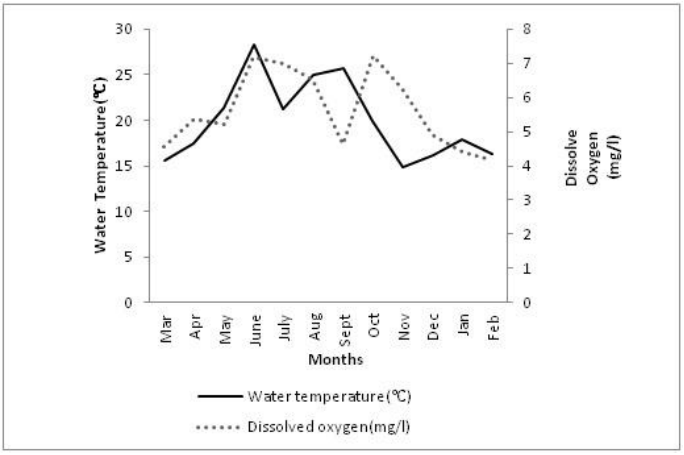

FIGURE 3. Average water temperature (ºC) and dissolved oxygen (mg/l) values in Sakaryabaşı-West Pond during the study

The differences in the average water temperature values, dissolved oxygen concentrations, conductivity and pH values according to the months were found statistically significant ($p < 0.05$), while the differences in the same parameters between the two stations were not statistically significant according to the t-test ($p > 0.05$). However, the differences in the depth values of stations by the months were found statistically insignificant ($p > 0.05$), but the differences between two stations in the months were found significant ($p < 0.05$). Average transparency values according to the months and the stations were both found to be significant statistically ($p < 0.05$) (Figure 4).

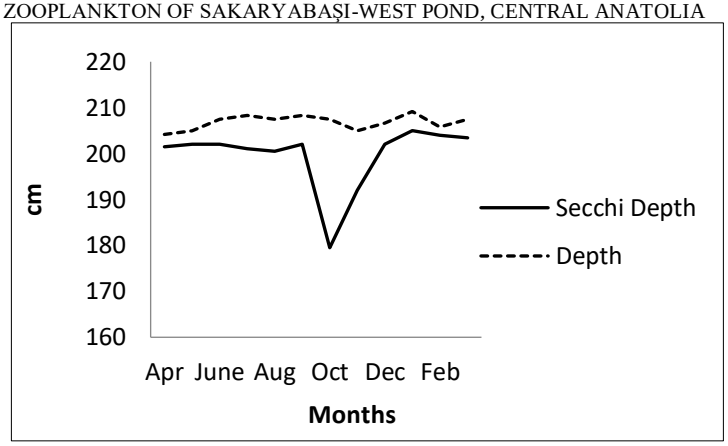

FIGURE 4. Average water depth (cm) and transparency (cm) values in Sakaryabaşı-West Pond during the study

4. CONCLUSION AND DISCUSSION

The zooplankton composition of Sakaryabaşı-West Pond was determined initially by [4]. The researchers reported totaly 25 zooplankton species, including 22 species from Rotifer, 2 species from Cladocera and one from Cyclopoid Copepoda. One year later, grass carp was stocked to the same pond for macrophyte control and the effects of grass carp on the other biological communities and water quality were investigated. In that study, as an indirect effect of aquatic plant elimination of grass carp, zooplankton species richness were decreased and the community consisted of totally 12 species; 10 Rotifera, 1 Cladocera and 1 Copepoda [6]. Over the years, the grass carp has disappeared from the pond with anthropogenic effects. Thus, zooplankton composition was found to be similar in this study to the findings of the [4]. In all three studies, the dominant group in zooplankton is Rotifera.

In zooplankton community, the most frequently found species from Rotifera was *Mytilina ventralis* (5.03%), *Lepadella lunaris* (4.52%) and *Collotheca ornata* (4.02%), respectively. Those three dominant rotifers species can be find in various trophic levels and are generally cosmopolitan species, seen in shallow waters with intense submerged plants [14]. *Ascomorpha ecaudis, Colurella obtusa, Keratella cochlearis, Lecane hornemani, Lecane luna, Lecane obtusa, Notholca acuminata, Pompholyx sulcata, Testudinella elliptica* were found once during the research. [4] reported that *Lecane luna* and *Lepadella patella* were found every month, *Asplanchna* sp., *Brachionus* sp., *Cephalodella gibba, Colletheca pelagica, Colurella obtusa, Euchlanis dilatata, Hexarthra* sp., *Keratella cochlearis, Lophocharis*

salpina, Monostyla lunaris, Mytilina mucronata, Notholca acuminata, Polyarthra dolichoptera, Proales daphnicola, Squatinella mutica, Trichotria pocillum, Trichocerca cylindrica, Trichocerca relicta, Testudinella sp. were found a few times during their study in Sakaryabaşı-West Pond. Kırkağaç and Demir [6], stocked grass carp and also placed a cage without fish in the Pond and reported that there was no differences in zooplankton composition and species richness (*Ascomorpha* sp., *Cephalodella gibba, Colurella obtusa, Lecane luna, Lepadella patella, Monostyla bulla, Mytilina mucronata, Testudinella* sp, *Trichocerca* sp.) neither inside the cage nor outside the cage in Sakaryabaşı-West Pond.

It is seen that the species richness of the Rotifera showed a change over the years. *Ascomorpha ecaudis, Collotheca ornata, Keratella valga, Lecane bulla, Lecane flexilis, Lecane furcata, Lecane hornemani, Lecane obtusa, Mytilina bisulcata, Mytilina ventralis* ve *Pompholyx sulcata* were reported first time only in this research. However, the findings about Cladocera species richness, is same with the results of [4]. *Alona rectangula* was not reported by [6], but in this study it was determined again. *Cyclops* sp. from Copepoda found mostly in nauplii stage, this is is similar to the results of the other studies.

Due to anthropogenic effects of Sakaryabaşı-West Pond, it is thought that the variations in zooplankton composition and species richness were effected indirectly from fishing activities. However, it was considering that the factors such as winds and water birds could cause the variation in Rotifera species [23]. Annual estimation of zooplankton composition in lakes and reservoirs is not always predictable. The time period in which each zooplankton species is most intense throughout the year can be variable [24]. Planktivorous organisms and the increases in the amount of nutrients can change the balance among the species which is another important factor in differentiation of the zooplankton composition. Besides this, elimination of invertebrates and planktivorous fishes by fishing causes significant variations in zooplankton community [25].

Zooplankton abundance was changed between 3 ± 0.5 x10^3 and 36 ± 2 x10^3 individual/m^3 during the study. The highest abundance value was in October, whereas the lowest one in January Demir ve Kırkağaç [4] reported the average zooplankton abundance about changing between 1 and 43 individual l^{-1}, reached to its highest abundance value in July, the lowest one in November. [6] determined the plant biomass increased 7 times in the cage without grass carp compared to the outside of the cage, and the average zooplankton abundance was generally high in the Pond; changed between 2 and 16 individual / l inside the cage and 3 and 52

individual / l outside the cage. The highest values were reached in July in the cage, in September outside the cage, and the lowest values in April and March, respectively.

In this study, the average zooplankton abundance values remained within the values ranges given in the other two studies. However, the variations of zooplankton abundance values in months were not found to be similiar. The structure and seasonal distribution of zooplankton communities in the pond are thought to vary depending on various factors such as the meteorological and hydrological parameters, the coastal areas exposed to human effects and the presence of macrophytes.

In Sakaryabaşı-West Pond, average water temperature values changed between 14.80±0.65°C and 28.56±0.55 °C. The highest value was measured in June, the lowest one in November. It was reported that pond mixing constantly by feding source, so there is no thermal stratification and average water temperature changes between 13° C (November) and 24° C (August) [4,6]. [26] made seasonal measurements in Sakaryabaşı-West Pond and reported the lowest water temperature was about 17.48°C in January and the highest one in July as about 20.10°C. It is thought that the lowest water temperature value and the season that measured were not changed by the years in the pond due to feed by geothermal spring, But upper limits of water temperature and the season to measure can vary because of the water volume of the pond, its stagnant water character, the seasonal variability of the water surface exposed to sunlights and the shallow lake feature. In this study, zooplankton abundance was increased with the water temperature rises. It was reported that water temperature is limiting factor of zooplankton distribution and encouraged the phytoplankton and zooplankton production in springs [27].

In Sakaryabaşı-West Pond, averaged dissolved oxygen concentrations changed between 4.18±0.20 mg/l and 7.41±0.85 mg/l during the study. Dissolved oxygen values determined in the study weren't similiar with the previous studies in the pond [4,6,25]. While the water temperature and dissolved oxygen values are expected to show an inversely change in water bodies, the water temperature and dissolved oxygen values increased together in April, May and June in this study. It is thought that the macrophytes and the sampling time in the pond caused increasing in both parameters. It is reported that dissolved oxygen concentration is the one of the limiting factor of zooplankton abundance [28].

During the study, the average pH values changed between 6.44±0.02 and 8.15±0.15. It is seen that the lowest and highest pH values in the Pond were measured in this study when compared with the previous studies in the pond [4,6,25]. In zooplankton distribution, pH is important. *Keratella cochlearis tecta* is inhabitant of alkaline

waters [29]. It was reported that acidity waters caused decreases in biomass of cyclopoids [30]. In this study, *Keratella* and *Trichocerca* from Rotifera represented with various species and cyclopoids from copepoda mostly in nauplii stage in high abundance were determined.

In Sakaryabaşı-West Pond, conductivity was measured between 0.71±0.01 µS/cm and 0.85±0.03 µS/cm during the study. It is reported that there is a positive correlation between zooplankton biomass and conductivity [31].

During the study, the depth and the transparency of the stations were measured in the pond. The values were both found to be lower than the values reported by [5] and [4]. Those differences in water depth is due to the measurement locations. Sakaryabaşı-West Pond and around of the pond are sometimes subject to recreational regulations. In this study, Çifteler Municipality removed the emergent *(Pragmites* sp.) and submerged macrophytes by the mechanical method from the Pond in September and this regulation caused the increase of turbidity in the Pond.

According to the results of some physical and chemical properties, Sakaryabaşı-West Pond was generally classified as "middle water" between II and III water classes in Continental Surface Water Quality Management [32].

Zooplankton distribution of wetlands depends on the seasons which are associated with daylight, presence and quantity of the food, water clarity, fish composition and size. The zooplankton composition of Sakaryabaşı-West Pond that was determined in 2005, was changed by the manipulation of the pond for controlling macrophytes by herbivorous fish. Any application or irrigation in the lakes and ponds, sediment deposits, agriculture and domestic wastes that may occur in lakes and ponds will affect the trophic level of the waters, therefore, the composition and abundance of zooplankton. Zooplankton of Sakaryabaşı-West Pond should be monitored regulary as an indicator of the ecological health. This is important for the protection and sustainability of the Sakaryabaşı-West Pond.

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